Preliminary Archaeological Evidence for a Decrease in White-Tailed Deer Body Size in New York during the Holocene

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*Estimates of white-tailed deer (*Odocoileus virginianus*) live weight are derived from the measurement of the astragalus bone from three prehistoric sites in central New York State: the Hiscock Site in Byron, Genesee County; the Lamoka Lake Site in Tyrone Township, Schuyler County, and the Cole Gravel Pit Site in Caledonia Township, Livingston County. Results from the three sites are then compared to each other, to body size estimates derived from deer bones at the Engelbert Site (Beisaw 2007) in Nichols, Tioga County, and to modern deer populations in New York State. The results suggest a decrease in the average live weight of deer between the Late Archaic and the Late Woodland/Proto-historic periods.*

Introduction

The study of variation in the body size of animals has provided valuable ecological, physiological, and archaeological data (e.g., Damuth and MacFadden 1990; Puputi and Niskanen 2008; Reitz and Wing 1999:172). Changes in the body size of white-tailed deer (*Odocoileus virginianus*) (Purdue 1983, 1986, 1989; Purdue and Reitz 1993; Rue 1980) have been linked to climate change, latitude, habitat productivity, population density, and predation pressure (Purdue and Reitz 1993; Severinghaus 1979; Wolverton et al. 2009; Yerkes 2005:249). Body size is not only informative on deer ecology. Since white-tailed deer have been one of the most important prey species used by humans in the eastern United States, knowledge of deer body size and how it has changed over time is likely to provide valuable information on human foraging efficiency and adaptation to the environment.

The weight of a deer is one measure of body size, but so many variables affect deer weight that it is difficult to accurately estimate the weight of a single individual at time of death from archaeological faunal remains. Weight is affected by numerous factors, including the age and sex of the individual, food availability, season, weather, and reproductive status (e.g., Hesselton and Sauer 1973; Moen and Severinghaus 1981; Rue 1980). Bones grow slowly, but body weight can fluctuate rapidly in response to changing conditions, and an animal may continue to gain weight after a bone has reached its maximum size.

Keeping these caveats in mind, Purdue (1986, 1987) developed a method of estimating deer body size from the astragalus, a compact bone from the lower hindlimb that preserves well in archaeological sites. Using white-tailed deer bones from archaeological sites, Purdue has provided evidence that, in the Midwest, deer were relatively small during the Middle Holocene and became relatively larger during the Late Holocene (Purdue 1989, 1991). In contrast, deer in the southeastern United States decreased in size over approximately the same time period (Purdue and Reitz 1993). In both cases, the change in size is linked to changes in availability of high-quality food due to changes in climate.

In this paper, deer live weight estimates are derived from bones from three sites in central New York State: the Hiscock Site in Byron, Genesee County, the Lamoka Lake Site in Tyrone Township, Schuyler County, and the Cole Gravel Pit Site in Caledonia Township, Livingston County (Figure 1). Results from the three sites are then compared to each other, and to body size estimates derived from deer bones at the Engelbert Site (Beisaw 2007) in Nichols, Tioga County, New York (Figure 1).

Methods

Calculation of deer live weight followed methods developed by Purdue (1987). The estimates derived from this equation are considered an approximation of the Fall-Early Winter

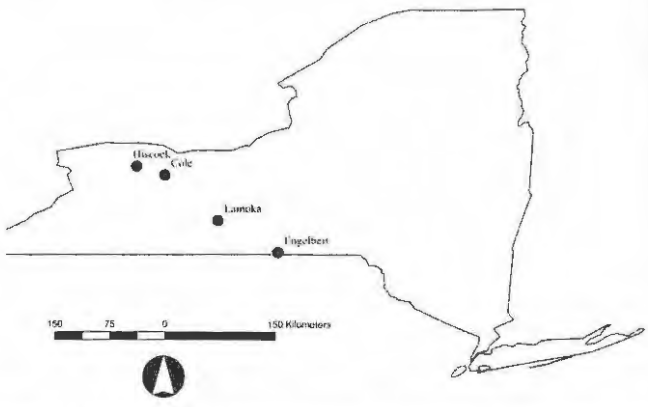

Figure 1. Map of New York State showing the location of sites used in this study.

live weight of deer in good health. The live weight of an animal is the weight of the entire individual, including all internal organs and blood. Dressed weight (also known as hog-dressed weight [Hamerstrom and Camburn 1950; Rue 1980:111]) is the weight after blood and both lower (e.g., stomach, intestines, and reproductive organs) and upper (e.g., heart, lungs, windpipe) internal organs have been removed. Live weight can be estimated from dressed weight using regression equations derived from direct measurement of deer (e.g., Hamerstrom and Camburn 1950; Hesselton and Sauer 1973:89).

Other terms used to describe partially butchered deer are sometimes used imprecisely. Field dressed weight is the weight of a deer after the lower internal organs have been removed (Rue 1980:111), but is sometimes used interchangeably with dressed weight. The definition of other terms, such as hanging weight and carcass weight, can vary, but generally exclude body parts like the upper internal organs, the head, feet, and skin.

Purdue measured bones from the lower leg of over 200 modern deer from eight localities. Live weights of deer were either directly measured or derived from dressed weights (Purdue 1987:3). Three measurements were taken from each astragalus: distal width (ASDW), medial depth (ASMD), and medial length (ASMLEN). Astragalus volume (ASVO) was calculated using the formula:

$$ASVO = (ASMD/2) \times (ASMLEN/2) \times ASDW \times pi$$

Regressions for estimating deer weight were then calculated (Purdue 1987: Table 5). Because of the difficulty in determining sex from individual astragali, the regression for combined sexes (where BW=body weight) is used:

$$Ln\ BW = -9.49655 + (1.40109 \times ln\ ASVO)$$

Purdue's (1987) methodology was used here to calculate deer live weight from the following site samples of astragali. Samples were limited to astragali from which the necessary measurements could be taken and that did not show evidence of burning or other modification that might affect measurement.

Results

Hiscock Site–Early Holocene

At the Hiscock Site, one astragalus was found in proximity to over 200 other deer bones, most of which are thought to represent a single partially complete deer skeleton aged one to one and a half years old (Madrigal 2003). This deer is thought to have been killed by a carnivore, as opposed to human hunting (Madrigal 2003). The bones were recovered in or at the base of a Holocene peat unit known as the "Woody Layer." An unconformity separates the "Woody Layer" into an older horizon that dates to approximately 9000–8000 B.P. and a younger horizon that dates to approximately 2000–500 B.P. (Laub 2003). The deer bones have not been directly dated, but as many of the deer bones in the "Woody Layer" were found resting on the top of the "Cobble Layer" and "Fibrous Gravelly Clay," both of which date to the Pleistocene (Laub 2003), these deer bones are thought to date to the earlier part of the Holocene. The single Hiscock astragalus is from an individual with an estimated live weight of 66.0 kg.

Lamoka Lake Site–Late Archaic

Several excavations have taken place at the Lamoka Lake Site beginning in the 1920s (Gramly 1983; Ritchie 1932, 1969; Madrigal 2001). Based on eight radiocarbon dates obtained from the site between 1951 and 1962 (Ritchie 1969:43) and three radiocarbon dates obtained from the site in 2000 by Rutgers University, the Late Archaic

Table 1. Summary of deer live weight estimates. S.D. = standard deviation (Engelbert data from Beisaw 2007: Table 25). "Combined Lamoka LA" includes all specimens from RMSC Lamoka LA, UC Lamoka LA, and BMS Lamoka LA (see Appendix).

Assemblage	N	Average Wt (kg)	S.D.	Range (kg)	Approximate Age (years B.P.)
Hiscock	1	66.0	—	—	9000–8000
Combined Lamoka LA	49	77.0	19.5	47.6-155.3	4300–4500
RMSC Lamoka LA	*39*	*76.9*	*19.3*	*52.3–155.3*	*4300–4500*
UC Lamoka LA	*5*	*71.5*	*20.6*	*47.6–94.7*	*4300–4500*
BMS Lamoka LA	*5*	*83.7*	*22.8*	*57.9–115.0*	*4300–4500*
RMSC Cole LA	8	75.7	18.0	55.5-112.6	~3900
BMS Lamoka W	6	76.8	14.0	62.6–94.1	1300–1000
Engelbert	38	64.5	18.6	34.4–119.2	870–330

(LA) occupation at Lamoka Lake Site dates to approximately 4300–4500 B.P.

Astragali dating to the Late Archaic at Lamoka Lake were obtained from three separate excavations. The RMSC Lamoka LA sample consists of 39 astragali from which measurements could be taken. These were obtained from some of the first excavations conducted at the site in the 1920s by the Rochester Museum of Arts and Sciences, now the Rochester Museum & Science Center (Ritchie 1932; Madrigal 1999). The BMS Lamoka LA (Late Archaic) sample was excavated from Lamoka Lake in the 1980s by the Buffalo Museum of Science (Gramly 1983; Madrigal 2000) and consists of five astragali. The UC Lamoka LA sample was excavated in 1990-1991 by Utica College (Madrigal 1999, 2001) and consists of five astragali.

Based on astragali measurements, the estimated live weight of deer from the RMSC Lamoka Lake LA assemblage ranges from 52.3 to 155.3 kg, with an average of 76.9 kg. The average weight of deer from BMS Lamoka LA is 83.7 kg (range: 57.9–115.0 kg) and from UC Lamoka LA is 71.5 kg (range: 47.6–94.7 kg) (Table 1). An Analysis of Variance (ANOVA Single Factor) indicates that there is not a statistically significant difference ($F=0.485297$, $p=0.61863$) between the three Late Archaic (LA) Lamoka Lake Site assemblages: RMSC Lamoka LA, UC Lamoka LA, and BMS Lamoka LA. Therefore, for the rest of the paper, these three samples are combined into a single Late Archaic assemblage (Lamoka LA) that consists of 49 astragali with an average estimated body size of 77.0 kg (Table 1).

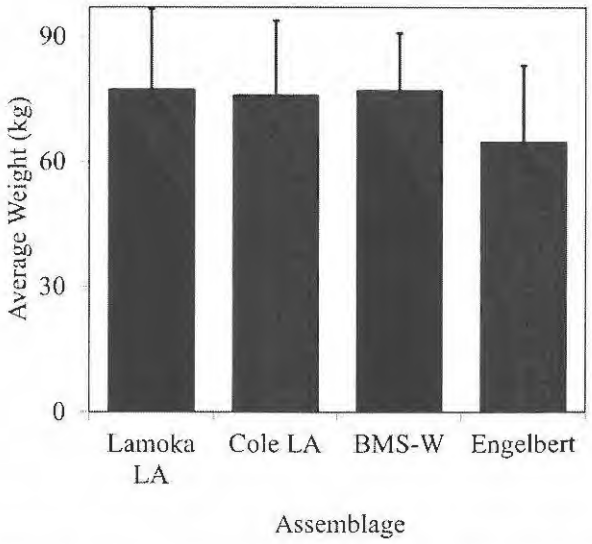

Figure 2. Estimated average live weight (with one standard deviation) of white-tailed deer by assemblage. Engelbert Site data from Beisaw 2007.

Lamoka Lake Site–Middle Woodland

A separate Middle Woodland occupation has also been identified at Lamoka Lake (Gramly 1983). No radiocarbon dates are associated with this occupation at the Lamoka Lake Site, but based on associated artifacts, the Woodland Period occupation at the site dates to approximately 1300–1000 B.P. (Gramly 1983; Madrigal 2001). The Buffalo Museum of Science sample (BMS Lamoka W) consists of six astragali. The average deer weight calculated from the BMS Lamoka W assemblage is 76.8 kg with a range of 62.6 to 94.1 kg (Table 1).

Cole Gravel Pit Site–Late Archaic

The Cole Gravel Pit Site was excavated by the RMSC between 1966 and 1971 following the identification of archaeological remains during commercial gravel stripping. A total of 296 features and 16 human burials were excavated (Hayes 1966; Hayes and Bergs 1969). Artifacts from the site are consistent with a Late Archaic occupation (Hayes 1966; Hayes and Bergs 1969; Madrigal 2006) and radiocarbon dates of 3890 ±120 B.P. (Y-2346) and 3980 ±160 (Y-2345) were obtained from two different features at this site (Hayes and Bergs 1969). Therefore, the Cole sample is attributed to approximately 3900 B.P. Eight astragali from the site (RMSC Cole LA) were measured. Estimated deer weights range from 55.5–112.6 kg with an average of 75.7 kg.

Engelbert Site–Late Woodland

The Engelbert Site has a complex history of occupation, excavation, and interpretation; however, the bones in question can be broadly attributed to a Late Woodland to Protohistoric time period, or approximately 870 to 330 B.P. (see Beisaw 2007 for a detailed analysis of the Engelbert Site chronology). Beisaw (2007) obtained measurements from 38 astragali from non-burial contexts at the Engelbert Site. Body size estimates range from 34.4 to 119.2 kg with an average weight of 64.5 kg.

Site Comparisons

The deer from the Hiscock Site is smaller than the average deer from all other assemblages except the Engelbert Site, but is within the range of variation seen in all assemblages and fits into the most abundant weight class (60.1-70 kg) at Lamoka Lake (LA). Because only a single specimen was measured, no firm conclusions regarding deer body size during the early Holocene can be drawn.

There is no statistically significant difference in deer body size between the two Late Archaic sites (Combined Lamoka LA and RMSC Cole LA: $F=0.034096$, $p=0.854181$). Nor is there a significant difference between

Table 2. Frequency distribution of deer body size estimates. (Engelbert data from Beisaw 2007:Table 25).

Weight (kg)	Lamoka LA	Cole LA	BMS W	Engelbert
30–40	0	0	0	2
40.1–50	1	0	0	5
50.1–60	6	2	0	14
60.1–70	15	1	3	8
70.1–80	10	2	1	1
80.1–90	6	2	0	2
90.1–100	6	0	2	5
100.1–110	3	0	0	0
110.1–120	1	1	0	1
120.1–130	0	0	0	0
130.1–140	0	0	0	0
140.1–150	0	0	0	0
150.1–160	1	0	0	0
Total	49	8	6	38

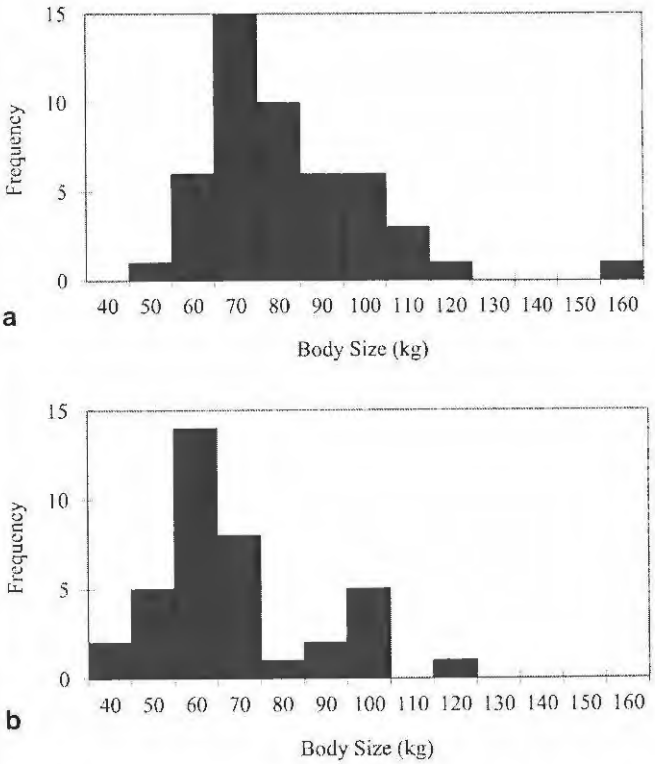

Figure 3. Distribution of estimated live weight of white-tailed deer from **a**. Lamoka Lake Site (LA) and **b**. Engelbert Site. Engelbert data from Beisaw 2007.

the BMS Lamoka W (Middle Woodland) assemblage and the two Late Archaic assemblages (Combined Lamoka LA: F=0.000732, p=0.97851; RMSC Cole: F=0.016364, p=0.90033) (Figure 2).

In contrast, deer from Lamoka LA are significantly larger (F=9.19; p=.003) than deer from the Late Woodland/Protohistoric Engelbert Site (Figure 2). There is no statistically significant difference between Engelbert and the two other assemblages (RMSC Cole LA: F=2.406985, p=0.127959; BMS Lamoka W: F=2.393748, p=0.129324). Note that the small number of astragali identified from RMSC Cole LA and BMS Lamoka W may have had an effect on these comparisons.

The frequency distribution of body size estimates was also examined (Table 2). For Combined Lamoka LA there is a unimodal distribution, with the most abundant size range beiug 60.1 to 70 kg (Figure 3). In contrast to the Combined Lamoka LA sample, there is an apparent bimodal distribution in the deer from the Engelbert Site (Figure 3). At this site, the two peaks may represent male and female deer (Beisaw 2007:220). Sample size for the RMSC Cole LA and BMS Lamoka W assemblages are too small to be enlightening, but are presented in Table 2 and appear to be generally consistent with the Combined Lamoka LA sample.

Discussion

Focusing on the two largest assemblages, the data show a distinct difference in estimated deer size between the Late Archaic and the Late Woodland/Protohistoric periods in central New York. Average deer size decreases by 16.3%, from 77.0 kg during the Late Archaic at Lamoka Lake to 64.5 kg during the Late Woodland/Protohistoric at Engelbert. There is no evidence for a change in average deer size from the Late Archaic to Middle Woodland, although, as already mentioned, the small sample size of the Middle Woodland assemblage makes any conclusion tentative.

Native New York deer populations were greatly reduced or extirpated throughout much of the state by the late 1800s before populations began to increase again in the early 1900s (Severinghaus and Brown 1956). In general, the central and western portion of New York State has larger deer than either the Adirondack or Catskill regions of the state (Moen and Severinghaus, 1981; Severinghaus and Brown, 1956).

Hesselton and Sauer (1973) obtained live weights of deer at four locations in western (Chautauqua County), central (Seneca County), and southeastern (Delaware and Dutchess Counties) New York State. Average live weight of 1.5 year old males at the four locations ranged from 55.3 to 67.1 kg, and 1.5 year old females ranged from 52.6 to 57.6 kg. Data for older males was not available, but 2.5 yr old females ranged from 58.5 to 61.7 kg and females 3.5 years and older ranged from 61.2 to 64.0 kg.

In comparison, estimated average live weight for all Late Archaic Lamoka Lake deer (which presumably

includes males and females of all ages, including fawns and yearlings) is 77.03 kg, or about 10 kg greater than the largest average group (1.5 year old males from Seneca County) in Hesselton and Sauer's (1973) study. It is also about 25 kg greater than the average (51.8 kg) of all deer sex and age groups in their study. The Late Woodland Engelbert Site deer average is closer to that of twentieth-century deer, but still greater than that of almost all of the samples. This suggests that average deer size in central New York continued to decrease into the Historic period and at least up until the late twentieth century.

Finally, there is one major outlier among the Lamoka Lake Site deer. The largest astragalus (RMSC Lamoka (LA) #226) is calculated to have come from a white-tailed deer with a live weight of 155.3 kg, or 342.4 lbs, which would place it among the largest deer ever recorded in New York State. Late nineteenth-century records include a male deer killed in Franklin County with a dressed weight of 286 lbs (130 kg) and estimated live weight of 357 lbs (162 kg); one from Essex County with a dressed weight of 299.5 lbs (136 kg) and live weight of 375 lbs (170 kg); and one from Warren County with a weight prior to butchery (i.e., bad been bled) of 388 lbs (176 kg) (Seton 1909:70-71). All of these were from the northeastern part of the state. In the twentieth century, occasional white-tailed deer with actual or estimated live weights over 400 lbs (181 kg) have been shot by hunters in various Midwestern states (Rue 1980:129-130).

Conclusion

The data presented here suggest that the average size of white-tailed deer in New York has decreased from the Late Archaic period (approximately 4500 B.P.) to the Late Woodland/Protohistoric periods, and into the twentieth century. Yet with large samples from only two archaeological sites, any conclusions must be considered, at best, tentative. White-tailed deer are one of the most common animals identified at New York archaeological sites, and the astragalus is one of the bones most likely to survive taphonomic processes, so there is a great potential for additional research on deer body size in New York. Future research at sites of different time periods should add to the database and provide more information on how deer body size changed over time, and investigations into the reasons for these changes.

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Appendix

White-tailed deer astragali measurements.

Key
ASDW=distal width
ASMD=medial depth
ASMLEN=medial length
ASVO=volume
Hiscock: Hiscock Site
Lamoka: Lamoka Lake Site
Cole: Cole Gravel Pit Site
BMS: Buffalo Museum of Science
RMSC: Rochester Museum & Science Center
UC: Utica College
H: Early Holocene
LA: Late Archaic
W: Middle Woodland

Assemblage	Catalog Number	ASDW	ASMD	ASMLEN	ASVO	Live Weight (kg)
Hiscock-H	186	25.9	22.3	38.5	17464.5	66.0
BMS Lamoka LA	1	28.4	26.7	43.6	25966.1	115.0
BMS Lamoka LA	2	26.4	24.6	39.4	20096.7	80.3
BMS Lamoka LA	69	25.7	20.8	37.9	15912.0	57.9
BMS Lamoka LA	364	28.2	25.1	41.4	23015.1	97.1
BMS Lamoka LA	365	26.8	21.6	39.4	17913.3	68.4
RMSC Lamoka LA	222	25.3	23.5	38.0	17744.4	67.5
RMSC Lamoka LA	224	26.3	24.1	39.5	19663.5	77.9
RMSC Lamoka LA	225	24.3	23.0	37.6	16504.9	60.9
RMSC Lamoka LA	226	38.2	25.0	42.9	32177.4	155.3
RMSC Lamoka LA	228	24.0	22.3	37.3	15678.9	56.7
RMSC Lamoka LA	229	25.2	22.7	37.1	16668.3	61.8
RMSC Lamoka LA	233	27.7	22.7	39.2	19358.9	76.2
RMSC Lamoka LA	234	26.9	23.9	45.0	22722.3	95.4
RMSC Lamoka LA	235	26.6	23.7	38.8	19211.1	75.4
RMSC Lamoka LA	237	25.8	23.2	38.1	17911.1	68.3
RMSC Lamoka LA	238	26.1	24.6	38.5	19414.5	76.5
RMSC Lamoka LA	239	26.3	23.7	37.9	18553.8	71.8
RMSC Lamoka LA	241	27.2	24.1	40.4	20799.7	84.3
RMSC Lamoka LA	243	28.6	26.2	42.6	25070.7	109.5
RMSC Lamoka LA	246	24.8	23.5	38.9	17805.7	67.8
RMSC Lamoka LA	247	27.4	24.5	40.3	21247.7	86.8
RMSC Lamoka LA	250	23.4	22.0	36.6	14798.2	52.3
RMSC Lamoka LA	253	25.5	22.8	36.9	16849.7	62.7
RMSC Lamoka LA	255	26.5	24.6	38.5	19712.0	78.2
RMSC Lamoka LA	256	25.3	22.4	37.9	16869.3	62.8
RMSC Lamoka LA	257	25.5	23.1	39.0	18042.9	69.1
RMSC Lamoka LA	258	28.1	25.3	41.7	23283.7	98.7
RMSC Lamoka LA	259	28.7	25.7	40.8	23635.5	100.8
RMSC Lamoka LA	260	25.8	22.9	39.4	18282.7	70.3

Assemblage	Catalog Number	ASDW	ASMD	ASMLEN	ASVO	Live Weight (kg)
RMSC Lamoka LA	261	25.0	22.1	39.0	16923.4	63.1
RMSC Lamoka LA	262	26.0	22.1	38.3	17284.4	65.0
RMSC Lamoka LA	265	25.4	24.5	41.7	20381.0	81.9
RMSC Lamoka LA	267	28.3	25.5	40.4	22898.0	96.4
RMSC Lamoka LA	268	24.5	22.4	36.5	15732.5	57.0
RMSC Lamoka LA	269	25.5	22.6	38.6	17471.3	66.0
RMSC Lamoka LA	272	25.0	23.5	40.0	18456.9	71.3
RMSC Lamoka LA	273	24.4	21.4	37.3	15296.9	54.8
RMSC Lamoka LA	276	27.7	26.0	43.3	24492.4	106.0
RMSC Lamoka LA	278	26.2	23.8	38.5	18855.1	73.4
RMSC Lamoka LA	279	26.6	23.7	37.8	18715.9	72.7
RMSC Lamoka LA	280	25.3	22.5	37.3	16676.4	61.8
RMSC Lamoka LA	282	27.8	23.9	40.9	21343.0	87.4
RMSC Lamoka LA	283	26.3	23.8	36.7	18042.2	69.0
RMSC Lamoka LA	286	27.5	24.4	39.8	20974.7	85.3
UC Lamoka LA	50	27.6	25.0	40.5	21948.0	90.9
UC Lamoka LA	51	27.9	25.6	40.3	22606.8	94.7
UC Lamoka LA	52	25.3	23.5	37.8	17651.0	67.0
UC Lamoka LA	53	23.8	22.5	37.6	15813.8	57.4
UC Lamoka LA	54	22.5	21.4	36.6	13841.0	47.6
RMSC Cole LA	50	24.7	22.3	35.7	15444.0	55.5
RMSC Cole LA	441	25.3	25.5	39.1	19812.0	78.7
RMSC Cole LA	655	25.6	22.4	36.1	16258.7	59.7
RMSC Cole LA	1160	25.8	22.4	37.8	17157.3	64.3
RMSC Cole LA	1521	25.0	23.9	39.0	18301.7	70.4
RMSC Cole LA	1654	26.8	24.6	40.0	20711.9	83.8
RMSC Cole LA	1827	28.4	26.8	42.8	25585.1	112.6
RMSC Cole LA	2363	27.8	23.4	39.3	20079.0	80.2
BMS Lamoka W	416	25.9	22.5	38.1	17438.0	65.8
BMS Lamoka W	419	27.9	25.6	39.8	22326.3	93.1
BMS Lamoka W	1002	27.7	25.1	41.2	22497.8	94.1
BMS Lamoka W	1121	25.6	22.5	37.2	16828.9	62.6
BMS Lamoka W	1123	28.7	20.8	37.7	17675.7	67.1
BMS Lamoka W	1124	25.8	23.9	40.7	19710.7	78.2